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TARSAL AND OVIPOSITOR SENSILLA OF *HELIOTHIS VIRESCENS* AND *H. SUBFLEXA* (LEPIDOPTERA: NOCTUIDAE)

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Abstract.—Three types of sensilla are present on the tarsi of *Heliothis virescens* and *H. subflexa*; a long, fluted sensillum chaeticum and short and long sensilla trichodea. The number of these sensilla varies from tarsus to tarsus within a species and between species. Females of *H. virescens* have significantly more of each type than females of *H. subflexa* and the males of *H. virescens*. Tarsus II bears the most of each type of sensillum; tarsus III has the fewest. The ovipositor of each species does not differ in the types and number of sensilla. Long and short sensilla chaetica can be found on most areas of the ovipositor whereas the 5 or 6 sensilla trichodea are situated on the apex of each valve. The surface of each valve is covered by short, pointed microtrichia.

Key Words: Noctuidae, *Heliothis*, tarsus, ovipositor, sensilla

Olfactory receptors, contact chemoreceptors, mechanoreceptors and visual receptors that are situated on various insect body regions such as the antennae, legs and ovipositor are involved in host finding (Dethier 1982, Miller and Strickler 1984, Ramaswamy 1988). Little is known about the role of tarsi and ovipositor in selection of an oviposition site by adult Lepidoptera. Most of the early morphological and behavioral research on adult Lepidoptera dealing with host plant selection is on butterflies (Minnich 1921, 1922a, b, Fox 1966, Ma and Schoonhoven 1973, Calvert 1974, Calvert and Hanson 1983, Renou 1983).

Many species in the family Noctuidae are serious pests on a wide variety of important agricultural crops throughout the world but our knowledge is scarce about what role sensory receptors on the tarsi and ovipositor play in host-plant finding. Tarsal and ovipositor sensory receptors are known to have an important role in host plant selection in moths such as *Chilo partellus* (Swinhoe) and *Spodoptera littoralis* (Boisd.), by responding to various chemical and mechanical stimuli (Chadha and Roome 1980, Waladde 1983, Salama et al. 1984, Waladde et al. 1985). There are several important pest species in the genus *Heliothis*, at present only one paper (Ramaswamy et al. 1987) deals with the possible role of sensory receptors on the tarsi and ovipositor in host plant selection for oviposition of *H. virescens* (F.). The purpose of the present study is to provide information on the morphology, number and distribution of sensory receptors on the tarsi and ovipositor of *H. virescens*, which has a wide host plant range, and to compare this species to *H. subflexa*, which has a very restricted host plant range.

Materials and Methods

Specimens for scanning electron microscopy were fixed in 4% glutaraldehyde in Na-cacodylate buffer (pH 7.1) for 8 h at 4°C. They were washed in the same buffer and post-fixed in 2% osmium tetroxide for 24

Figs. 1–3. Tarsi of *H. virescens* female. 1, Tarsus I. 2, Tarsus II. 3, Tarsus III.

Table 1. Comparison of the number of sensilla on the tarsi of *H. virescens* females.

Tarsus	A	B	C
I	21.88 ± 0.83 b	42.75 ± 1.04 b	11.46 ± 0.52 b
II	23.63 ± 0.74 a	45.25 ± 0.89 a	12.81 ± 0.71 a
III	14.88 ± 0.64 c	32.50 ± 0.93 c	9.43 ± 0.67 c

A = sensillum chaeticum; B = short sensillum trichodeum; C = long sensillum trichodeum. Means within a column not followed by the same letter are significantly different ($P < 0.05$) as determined by ANOVA followed by Student-Newman-Keuls Test (n = 8).

h. After dehydration in a graded series of ethanol, the specimens were placed in pentane overnight and then air dried. The tarsi and ovipositors were sputter-coated with gold-palladium and examined with a JEOL JSM-35 CF scanning electron microscope at 20 kV.

The legs of eight female *H. virescens* and *H. subflexa* and eight male *H. virescens* were cleared in 7% KOH and mounted in euparal. The data on the number of sensory receptors on tarsi I–III are given as a mean plus the standard deviation and were subjected to ANOVA followed by Student-Newman-Keuls Test ($P < 0.05$). A *t*-test ($P < 0.05$) was used for the comparison of the number of sensory receptors on each tarsus of *H. virescens* and *H. subflexa* females and *H. virescens* female and male.

Results and Discussion

Tarsi.—The tarsi consist of 5 tarsomeres and a pretarsus. Scales cover the dorsal surface of each tarsus whereas on the ventral surface of each tarsus there is an area that is devoid of scales (Figs. 1–3). This area is the contact region between the tarsus and substrate. The total area that comes in contact with the substrate differs for tarsi I–III (Figs. 1–3). It is from this region that the number of various types of sensory receptors was counted. Tarsus II has the largest contact area and the greatest number of sensory receptors, followed by tarsi I and III (Figs. 1–3; Tables 1, 2).

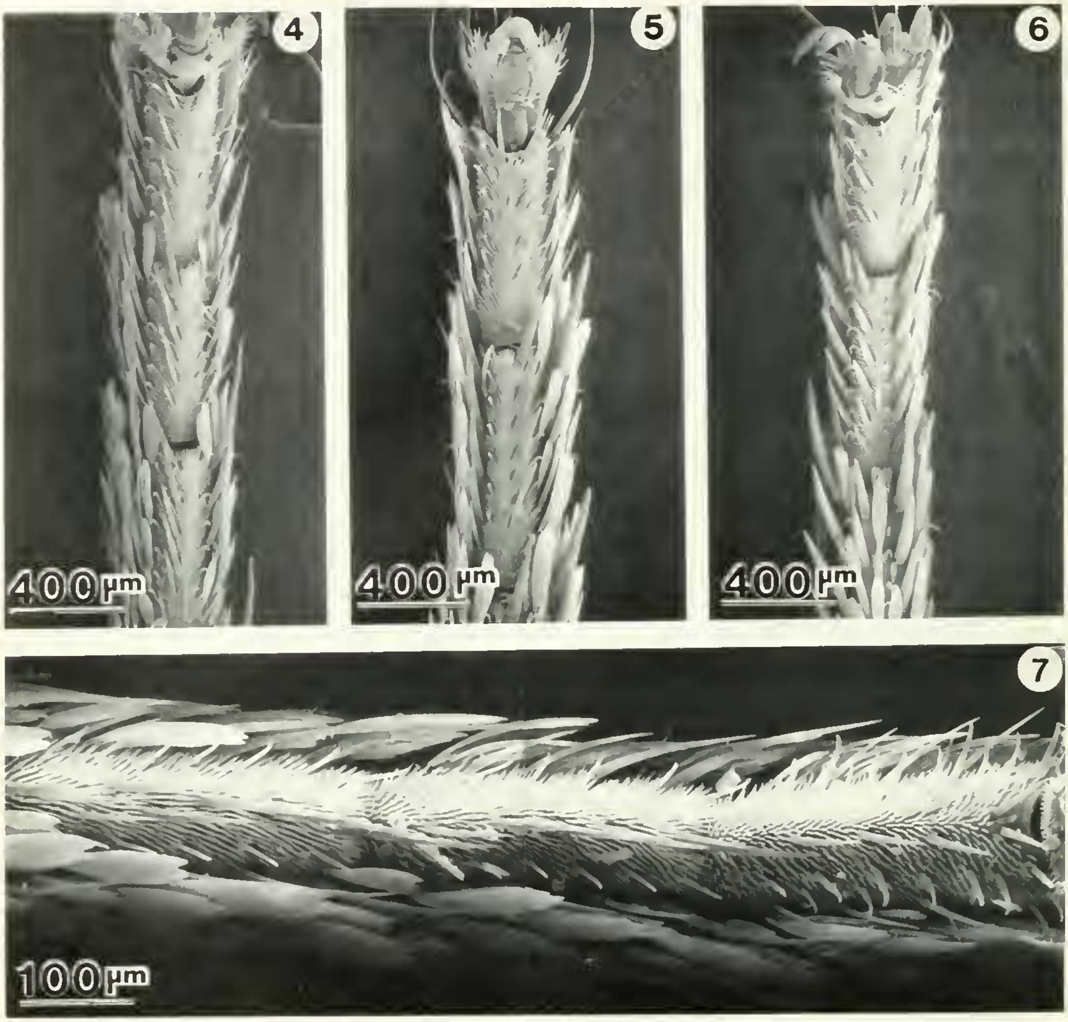
The long trichoid sensilla are also located on the periphery of the contact region and at the apex of tarsomere V (Fig. 1). Two long trichoid sensilla are apically located on tarsomere V on either side of the tarsomere midline (Fig. 1). This sensory receptor is 65–85 μm long and curves back in the direction of the body (Figs. 1, 8). A distinct cuticular pattern covers the surface of the sensillum from the base to the apex (Fig. 9).

On each tarsus there are 3 rows of sensilla chaetica, 1 row on each side of the contact region and the third row set off-centre on tarsus I and on the midline of tarsi II and III (Figs. 1–3). This pattern is the same for the female and male of *H. virescens* and *H. subflexa* female (Figs. 1–7). The sensillum

Table 2. Comparison of the number of sensilla on the tarsi of *H. subflexa* females.

Tarsus	A	B	C
I	18.13 ± 0.99 a	37.88 ± 0.83 a	9.31 ± 0.64 a
II	12.13 ± 0.98 b	28.00 ± 0.76 b	6.78 ± 0.81 b
III	11.75 ± 0.71 b	27.88 ± 0.64 b	6.12 ± 0.77 b

A = sensillum chaeticum; B = short sensillum trichodeum; C = long sensillum trichodeum. Means within a column not followed by the same letter are significantly different ($P < 0.05$) as determined by ANOVA followed by Student-Newman-Keuls Test (n = 8).

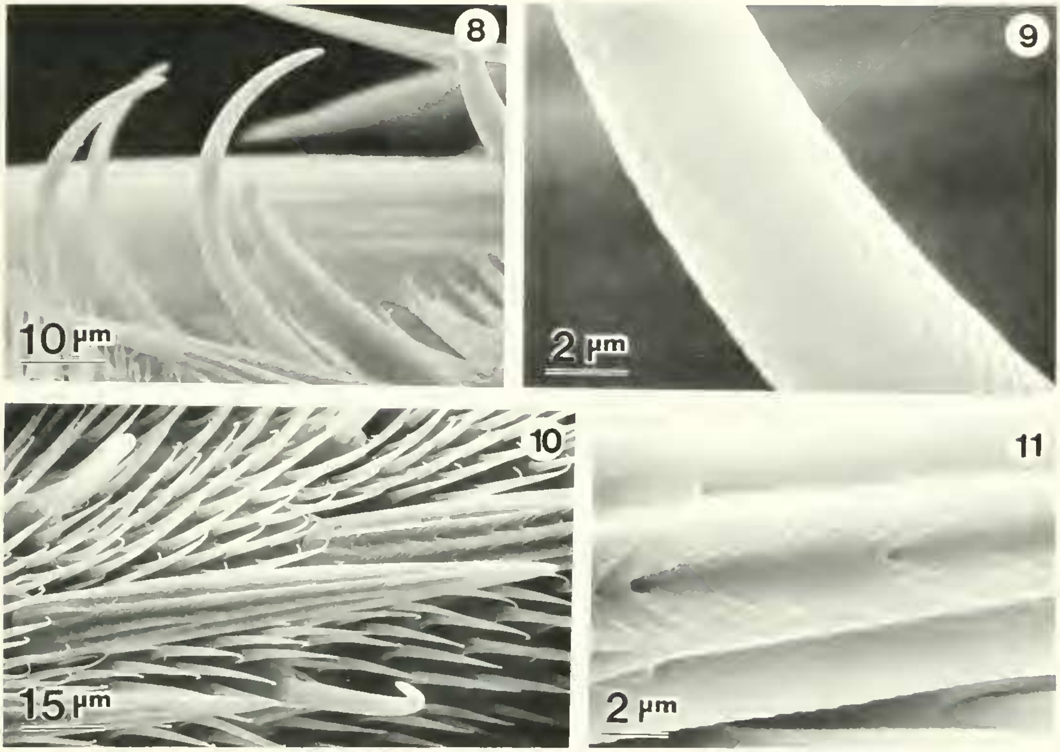


Figs. 4–7. 4–6, Tarsi of *H. subflexa* female. 4, Tarsus I. 5, Tarsus II. 6, Tarsus III. 7, Tarsus I of *H. virescens* male.

chaeticum has a socket at the base, tapers and slants downward in the direction of the pre-tarsus (Fig. 1). The surface of this sensory receptor has large, longitudinal ridges possessing secondary ridges on its surface and pits are situated at the base of the large ridges (Figs. 10, 11). This type of sensillum ranges from 80–165 μm long.

Two rows of short trichoid sensilla that are situated on either side of the central row of sensilla chaetica are on each tarsus in the contact region (Fig. 1). There are 2 distinct types of short trichoid sensilla. The first type if 42–46 μm long and 7–9 μm wide at the base and is slightly curved near the apex (Fig. 12). The receptor surface is covered with irregular longitudinal striations (Fig. 13). The second type of short trichoid sensillum is 39–43 μm long and 5–6.5 μm wide at the base, with the apical third distinctly hooked (Fig. 12). The receptor surface has irregular, lateral striations (Fig. 14).

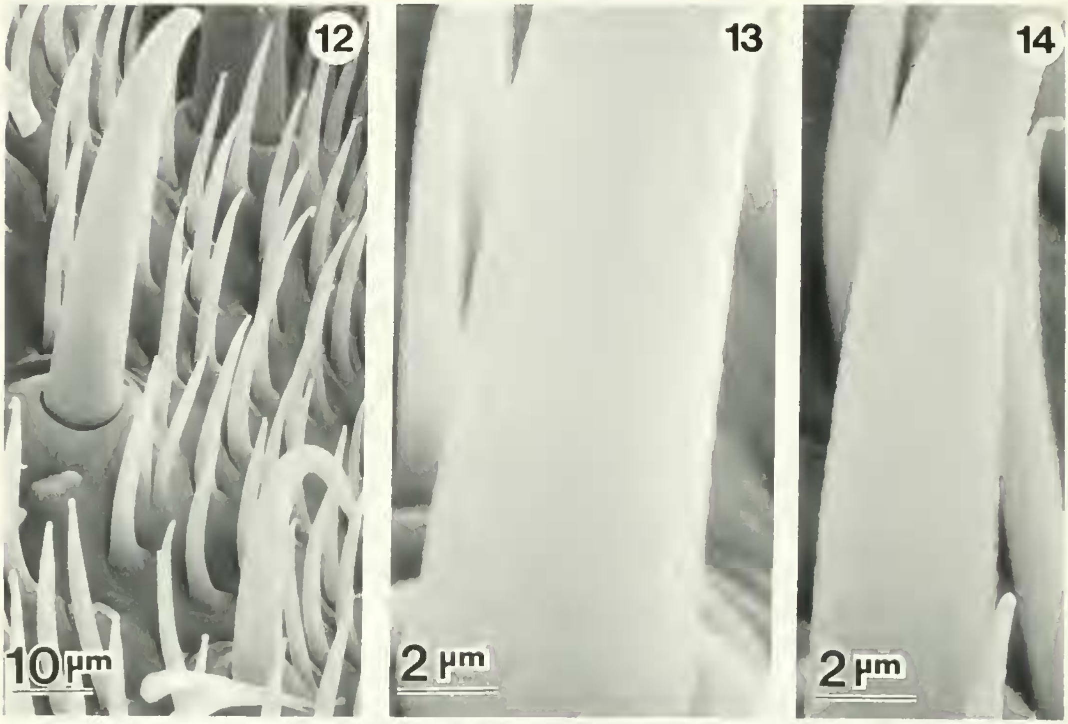
The distribution pattern and morphological types of sensilla that are found on the



Figs. 8–11. 8, Long sensilla trichodea. 9, Surface pattern on the long sensillum trichodeum. 10, Sensillum chaeticum. 11, Surface pattern on the sensillum chaeticum.

tarsi of female *H. virescens* and *H. subflexa,* and male *H. virescens* are similar in that each tarsus has 2 outer rows of sensilla chaetica and long trichoid sensilla, a central row of sensilla chaetica and a row of short trichoid sensilla on either side of the central row of sensilla chaetica (Figs. 1–7). The number of sensory receptors differs on each tarsus. In females of *H. virescens* and *H. subflexa* the number of sensilla chaetica and long and short trichoid sensilla show the same pattern in that tarsus II > tarsus I > tarsus III (Tables 1, 2). There is a significant difference between *H. virescens* and *H. subflexa* females in the number of sensory receptors on each tarsus in that *H. virescens* has the greater number of each sensillar type (Table 3). The pattern in the number of sensory receptors on the male tarsi of *H. virescens* differs from the female in that tarsus I has significantly more long and short trichoid sensilla and sensilla chaetica than tarsi II and III which have similar numbers of sensillar types (Table 4). Females of *H. virescens* have significantly more of all sensillar types than the males (Table 5).

Similar sensilla chaetica and trichodea on the tarsi of *H. virescens* and *H. subflexa* are also located on the tarsi of other moth species such as *Chilo partellus* and *Eldana saccharina* (Waladde 1983), and *Helicoverpa zea* (Callahan 1969), but there are no data on the distribution and number of each sensillar type on the tarsus of each leg. These types of sensilla are present on the tarsi of females and males of *Pieris brassicae* and the distribution pattern is similar to what is found on *H. virescens* and *H. subflexa.* The number of sensilla chaetica on the tarsi of *Chlosyne lacina* Geyer and *Heliconius*



Figs. 12–14. Short sensilla trichodea. 12, Straight and hooked forms. 13, Surface of the straight form. 14, Surface of the hooked form.

charitonius L. is greatly reduced, and this type of sensillum is often associated with a cluster of trichoid sensilla (Calvert 1974, Renou 1983).

Electrophysiological experiments on several species of Lepidoptera showed that the trichoid sensilla respond to salt, sugar and plant substances (Morita et al. 1957, Takeda 1961, Ma and Schoonhoven 1973, Renou 1983, Waladde 1983, Waladde et al. 1985). Behavioral tests involving the tarsi indicate the importance of tarsal sensory receptors for host plant acceptance and oviposition (Ma and Schoonhoven 1973, Calvert and Hanson 1983, Salama et al. 1984, Faucheux 1985).

The trichoid sensilla on the tarsi of *H. virescens* respond to salts, sugars and plant extracts (Ramaswamy and Hanson unpublished data), and behavioral experiments

Table 3. Comparison of the number of sensilla on the tarsi of *H. virescens* males.

Tarsus	A	B	C
I	18.38 ± 0.92 b	38.50 ± 0.93 b	9.71 ± 0.59 b
II	22.00 ± 0.76 a	42.88 ± 0.99 a	11.34 ± 0.68 a
III	12.63 ± 0.91 c	26.75 ± 1.49 c	8.18 ± 0.52 c

A = sensillum chaeticum; B = short sensillum trichodeum; C = long sensillum trichodeum. Means within a column not followed by the same letter are significantly different ($P < 0.05$) as determined by ANOVA followed by Student-Newman-Keuls Test (n = 8).

Table 4. Comparison of the number of sensilla on the tarsi of *H. virescens* and *H. subflexa* females.

Tarsus	A	B	C
H. v. I	21.88 ± 0.83 a	42.75 ± 1.04 a	11.46 ± 0.52 a
H. s. I	18.38 ± 0.92 b	38.50 ± 0.93 b	9.71 ± 0.59 b
H. v. II	23.63 ± 0.74 a	45.25 ± 0.89 a	12.81 ± 0.71 a
H. s. II	22.00 ± 0.76 b	42.88 ± 0.99 b	11.34 ± 0.58 b
H. v. III	14.88 ± 0.64 a	32.50 ± 0.93 a	9.43 ± 0.67 a
H. s. III	12.63 ± 0.92 b	26.75 ± 0.49 b	8.18 ± 0.52 b

A = sensillum chaeticum; B = short sensillum trichodeum; C = long sensillum trichodeum. Means not followed by the same letter are significantly different ($P < 0.05$) as determined by Student's-*t*-test (n = 8).

showed that the sensory receptors on the tarsi are involved in host plant acceptance and oviposition (Ramaswamy et al. 1987). *Heliothis virescens* oviposits on a wide variety of host plants, such as tobacco, cotton, peanut and tomato, whereas *H. subflexa* uses ground cherry. This difference is the number of host plants for oviposition may be due in part to the difference in the number of sensory receptors found on the tarsi of both species.

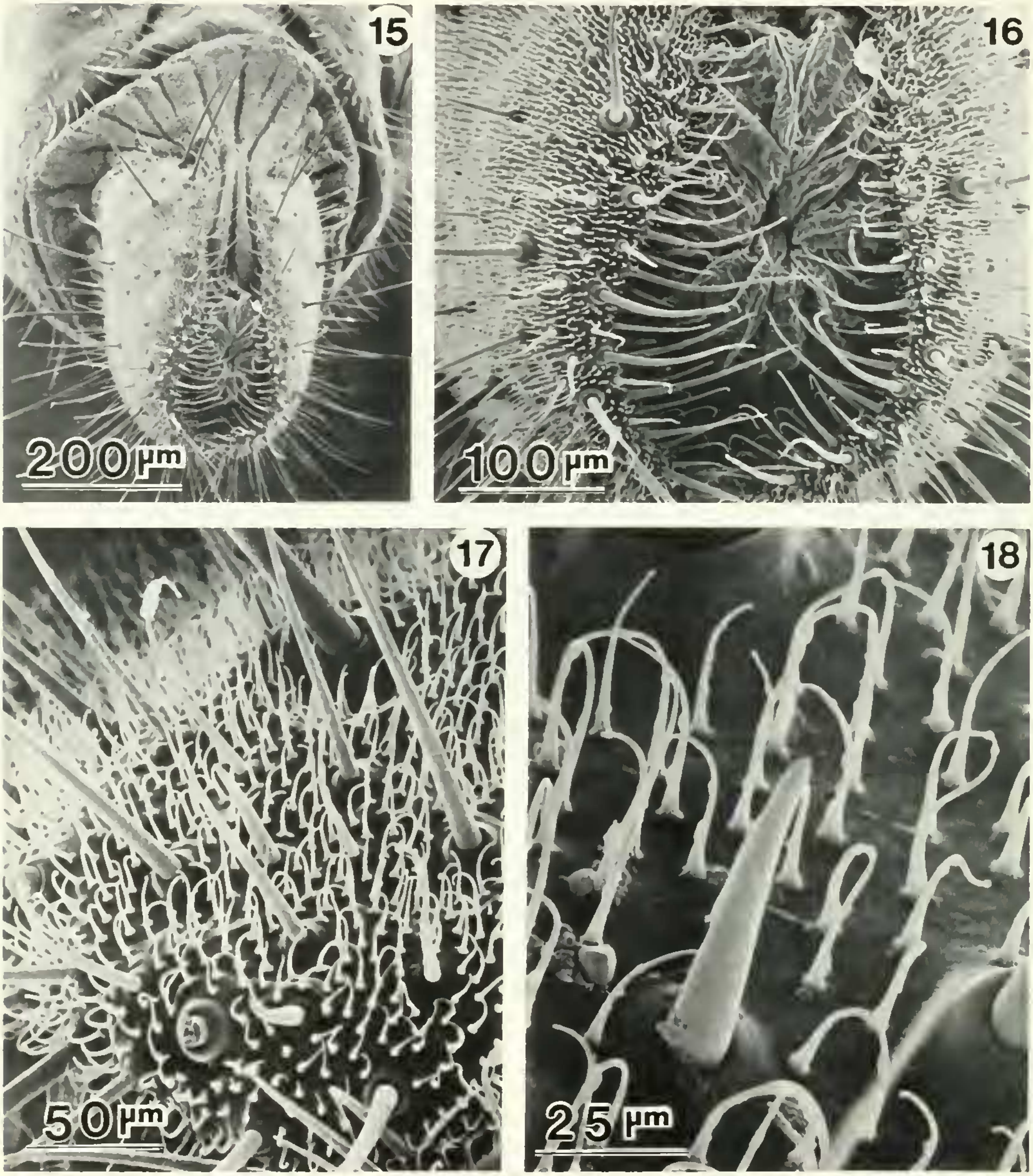
Ovipositor.—The ovipositor consists of two papillae anales that are on either side of the oviduct and anal openings (Fig. 15). The oviduct opening is surrounded by short and long sensilla chaetica which have tapered tips and smooth walls (Fig. 16). These sensilla are also situated on the rest of the ovipositor surface (Fig. 17). The apex of the ovipositor bears blunt-tipped trichoid sensilla which have shallow longitudinal grooves on the surface that-fade near the apex of the sensillum (Fig. 18). Each papillae anales has five to six of these trichoid sensilla. The remainder of the ovipositor surface is covered with microtrichia.

There are no differences in the morphology, number and distribution of the sensilla between *H. virescens* and *H. subflexa*. The trichoid sensilla on the ovipositor of *Phthorimaea operculella* (Zell.) (Gelechiidae) are contact chemoreceptors that are involved in oviposition on a suitable substrate (Fenmore 1978, Valencia and Rice 1982). Additionally these sensilla are present on the ovipositor of noctuid species such as *Chilo partellus* and *Spodoptera littoralis*, and morphological and electrophysiological data indicate that they are contact chemoreceptors (Chadha and Roome 1980, Waladde 1983, Waladde et al. 1985). But the exact role(s) these contact chemoreceptors

Table 5. Comparison of the number of sensilla on the tarsi of *H. virescens* females and males.

Tarsus	A	B	C
H. v. f I	21.88 ± 0.83 a	42.75 ± 1.04 a	11.46 ± 0.52 a
H. v. m I	18.13 ± 0.99 b	37.88 ± 0.83 b	9.31 ± 0.64 b
H. v. f II	23.63 ± 0.74 a	45.25 ± 0.89 a	12.81 ± 0.71 a
H. v. m II	12.13 ± 0.98 b	28.00 ± 0.64 b	6.78 ± 0.81 b
H. v. f III	14.88 ± 0.64 a	32.50 ± 0.95 a	9.43 ± 0.67 a
H. v. m III	11.75 ± 0.71 b	27.88 ± 0.64 b	6.12 ± 0.77 b

A = sensillum chaeticum; B = short sensillum trichodeum; C = long sensillum trichodeum. Means not followed by the same letter are significantly different ($P < 0.05$) as determined by Student-*t*-test (n = 8).



Figs. 15–18. Ovipositor of *H. virescens*. 15, Two papillae anales surrounding the anal and oviduct openings. 16, Short and long sensilla chaetica around the oviduct opening. 17, Sensillum trichodeum amongst the long and short sensilla chaetica. 18, Sensillum trichodeum with a slightly grooved surface.

play in oviposition behavior of the above mentioned species and *H. virescens* and *H. subflexa* needs to be determined.

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